Paper No. 20

THE EFFECT OF pH ON CIGARETTE SMOKE FILTRATION.

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ABSTRACT

In a previous paper (C. I. Ayres and S. R. Evelyn - 18th Tobacco Chemists' Conference, 1964) it was shown that the selective filtration of nicotine relative to total particulate matter (T.P.M.), by conventional cellulose acetate filters, is dependent upon the pH of the smoke presented to the filter. This phenomenon has now been studied in greater detail using cigarettes, the tobacco compositions of which have been varied in order to give smoke of differing pH values, and a range of filters treated so as to cover a range of pH. The results from this study have been interpreted in terms of a vapour concentration gradient between the smoke droplet and the filter surface, the slope of which is predominantly determined by the pH of the smoke and filter. It has been concluded, therefore, that the differing degrees of selective filtration of nicotine and certain other smoke constituents arise from (i) changes in the distribution of these smoke constituents between the vapour and particulate phases, (ii) the influence of pH in determining this distribution, and (iii) the rapid equilibration of the vapour-particulate distribution following removal of a smoke constituent from the vapour phase by filtration.

REVIEW BY J. S. OSMALOV

NOTE: This paper was read, and because of the large amount of material covered it was difficult to take very complete notes. The report on this talk, outlined below, covers only a portion of the total talk. A copy of this paper was requested from the authors; if permitted, they will send us one. They indicated the paper would be published.

In a previous paper Ayres and Evelyn showed that the selective filtration of nicotine was dependent on smoke pH. Selective filtration was studied in greater detail in this work, with emphasis on smoke pH, total nicotine, total alkaloid fraction, and steam volatile acids. For the experimental work,

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changes in smoke pH were accomplished by use of burley tobacco (high pH), flue-cured tobacco (low pH), and blends of these tobaccos. To achieve the desired filter pH, a non-volatile acid or base was used on the filter, the filter having been neutral before treatment. Cigarettes and filters used in all experiments were selected for constant weight and pressure drop. Particulate efficiency was determined from measurement of the oven-dried smoke condensate.

CA Filters

Particulate efficiency was found to increase as the pH of the filter increased. The best efficiency was achievable with the more acid smoke and an alkaline filter.

The filtration of nicotine was accounted for by three mechanisms as follows:

1. Mechanical interception.
2. Sorption from the vapor phase.
3. Distillation from particles to filter (and distillation from the filter to particles in certain instances).

Concentration of free nicotine in the vapor is proportional to the nicotine in the smoke. In both flue-cured and burley the concentration is small.

With neutral filters the mechanism for nicotine filtration is distillation; the efficiency is less than that with acid filters since the driving force is decreased with the neutral filter. With alkaline filters nicotine salts trapped on the filter go to free nicotine. This free nicotine opposes distillation of nicotine from the smoke particles to the filter and instead will distill from the filter to the particles.

The driving force or filtration potential of nicotine by acetate was illustrated in the following manner:

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FIGURE I

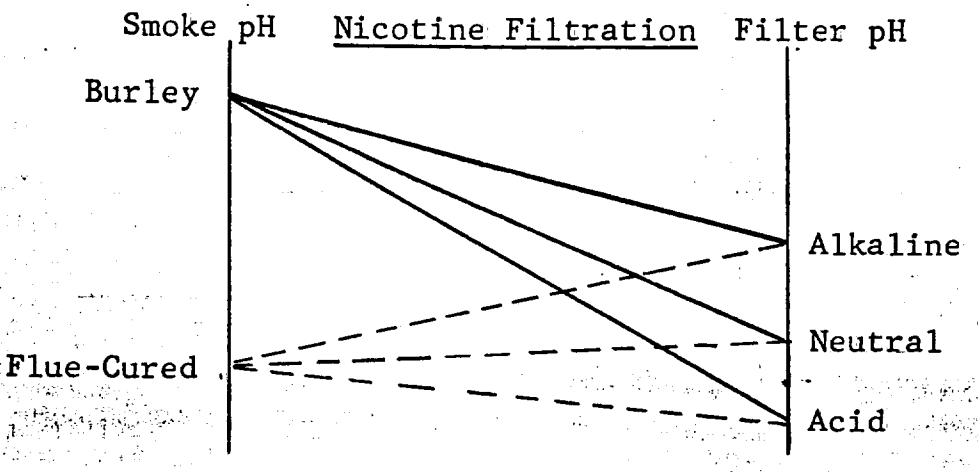

Table I summarizes nicotine filtration results obtained with various pH tobaccos and filters.

TABLE I

Cigarette Composition	Cigt. #1	Cigt. #2	Cigt. #3	Cigt. #4	Cigt. #5
% Burley	100	75	50	25	0
% Bright	0	25	50	75	100
pH of TPM	7.3	6.7	5.9	5.4	5.3
% Free Nicotine	23	6	1	0.3	0.2
% Nicotine Retained					
Filter Type					
Acid Acetate	26	18	11	7	3
Neutral Acetete	7	4	2	1	0
Alkaline Acetate	5	0	-1	-3	-4
Paper	3	1	1	0	0

Steam Volatile Acids

Filtration of the steam volatile acids increased with increasing pH of the filter. The authors reported that acetic acid accounts for 50% of these steam volatile acids. The alkaline filter holds the acids as salts. The filtration potential for these acids by acetate filters was illustrated as follows in Figure 2 and Table 2.

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FIGURE 2

Steam Volatile Acid Filtration

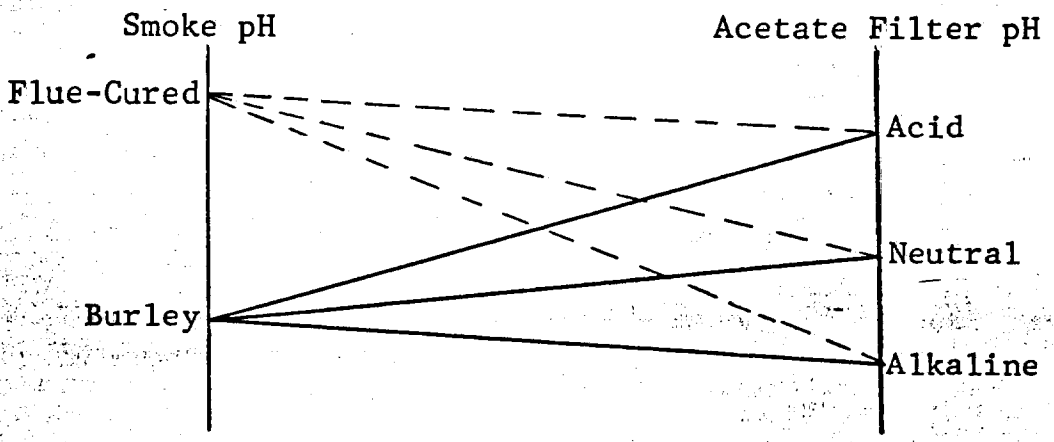

TABLE II

Cigarette Composition	Cigt. #1	Cigt. #2	Cigt. #3	Cigt. #4	Cigt. #5
% Burley	100	75	50	25	0
% Bright	0	25	50	75	100
pH of TPM	7.3	6.7	5.9	5.4	5.3
% Free Acids	0.3	1	6.5	18	26
% Free Acids Retained Filter Type					
Acid Acetate	-9	-7	-1	-1	3
Neutral Acetate	-2	-1	4	11	15
Alkaline Acetate	6	22	29	29	29
Paper	-17	-8	-3	4	4

Other comments included the following: As smoke pH decreases, the efficiency of CA goes up for phenols; however, filter surface area is more important than pH in phenol removal from smoke. For wet tar, as smoke pH decreases filtration decreases.

The pH of smoke was determined by washing the Cambridge pad with water and measuring the pH of the solution.

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There was selective filtration of nicotine relative to TPM on various types of filters. The different degrees of selective filtration of nicotine and certain other smoke constituents arise from (1) changes in the distribution of these smoke constituents between the vapour and particulate phases (2) the influence of pH in determining this distribution, and (3) the rapid equilibration of the vapour-particulate distribution following removal of a smoke constituent from the vapour phase by filtration.

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